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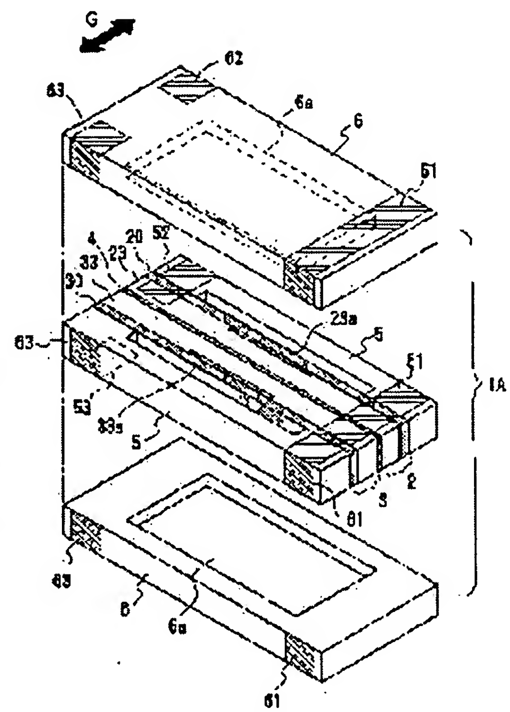
(54) ACCELERATION SENSOR



(57)Abstract:

PROBLEM TO BE SOLVED: To provide an acceleration sensor which is small-sized and has high detection sensitivity and moreover can have sensitivity with respect to only acceleration.

SOLUTION: The acceleration sensor 1A consists of a piezoelectric body which has electrodes formed on both main surfaces and equipped with 1st and 2nd resonators 20 and 30, which resonate at mutually independent frequencies and 1st and 2nd base plates 23 and 33; and the 1st resonator 20 is jointed with one surface of the 1st base plate 23 to constitute a 1st unimorph type acceleration detecting element 2 and the 2nd resonator 30 is jointed with one surface of the 2nd base plate 33 to constitute a 2nd unimorph type acceleration detecting element 3. The 1st and 2nd unifomrph type acceleration detecting elements 2 and 3 have both lengthwise ends fixed and supported, so that the 1st and 2nd resonators 20 and 30 face toward mutually reciprocal directions or opposite directions, and can flex independently in the application direction of acceleration. The two acceleration detecting elements 2 and 3 flex independently as the acceleration is applied, and frequency variations or impedance variations of the 1st and 2nd resonators 20 and 30 caused by the flection are detected differentially so as to detect the acceleration.

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審査請求　未請求　請求項の数９　ＯＬ　（全　８　頁）

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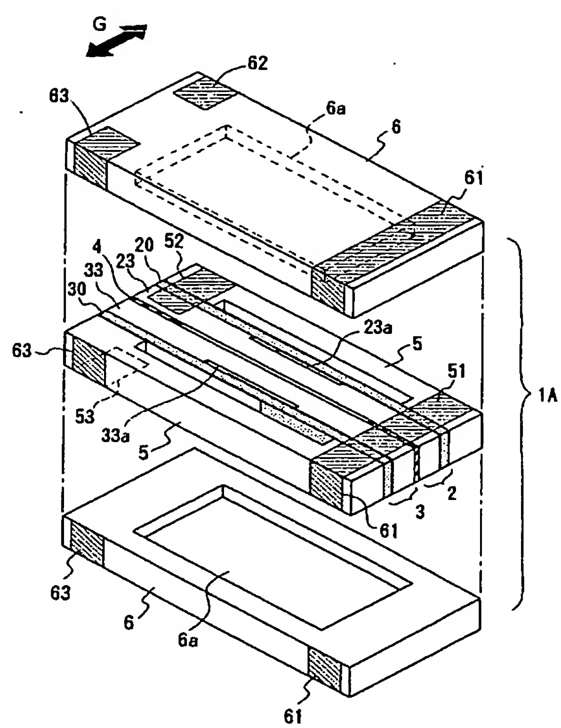
(54)【発明の名称】　加速度センサ

(57)【要約】

【課題】小型で検出感度がよく、しかも加速度に対してのみ感度を持つことが可能な加速度センサを提供する。

【解決手段】加速度センサ１Ａは、両主面に電極が形成された圧電体よりなり、それぞれ独立した周波数で共振する第１と第２の共振子２０，３０と、第１と第２のベース板２３，３３とを備え、第１の共振子２０を第１のベース板２３の一面に接合して第１のユニモルフ型加速度検出素子２を構成し、第２の共振子３０を第２のベース板３３の一面に接合して第２のユニモルフ型加速度検出素子３を構成する。第１と第２のユニモルフ型加速度検出素子２，３を、第１と第２の共振子２０，３０が互いに相反方向または対向方向を向き、かつ加速度の印加方向にそれぞれ独立して撓み得るように、長手方向両端部を固定支持する。加速度の印加により２つの加速検出素子２，３が独立して撓み、その撓みによって生じる第１と第２の共振子２０，３０の周波数変化またはインピーダンス変化を差動的に検出することにより、加速度を検出可能とした。



【特許請求の範囲】

【請求項１】両主面に電極が形成された圧電体よりなり、それぞれ独立した周波数で共振する第１と第２の共振子と、第１と第２のベース板とを備え、第１の共振子を第１のベース板の一面に接合して第１のユニモルフ型加速度検出素子を構成するとともに、第２の共振子を第２のベース板の一面に接合して第２のユニモルフ型加速度検出素子を構成し、第１と第２の加速度検出素子を、第１と第２の共振子が互いに相反方向または対向方向を向き、かつ加速度の印加によってそれぞれ独立して撓み得るように、長手方向一端部または両端部を固定支持してなり、加速度の印加により２つの加速検出素子が独立して撓み、その撓みによって生じる第１と第２の共振子の周波数変化またはインピーダンス変化を差動的に検出することにより、加速度を検出可能としたことを特徴とする加速度センサ。

【請求項２】上記第１，第２の加速度検出素子は、加速度の作用に伴う曲げ中性面が、共振子とベース板との接合面またはベース板側になるように設定されていることを特徴とする請求項１に記載の加速度センサ。

【請求項３】上記第１，第２の共振子は、その長さ方向中央部にエネルギーが閉じ込められる振動モード素子であり、第１，第２のベース板と第１，第２の共振子との間に、共振子の閉じ込め振動の範囲より広くかつ加速度によって撓む範囲より小さい空隙が形成されていることを特徴とする請求項１または２に記載の加速度センサ。

【請求項４】上記第１と第２の加速度検出素子の長手方向両端部はスペーサ層を介して対面接合され、第１と第２の加速度検出素子の加速度印加方向の外側面が、ケース部材によって覆われ、かつ第１と第２の加速度検出素子とケース部材とで形成される開放面がカバー部材によって覆われ、第１と第２の共振子に形成された電極は、ケース部材の表面に形成された内部電極を介してカバー部材の表面に形成された外部電極に接続されていることを特徴とする請求項１ないし３のいずれかに記載の加速度センサ。

【請求項５】単一のベース板の表裏面に、両主面に電極が形成された圧電体よりなる第１と第２の共振子を接合して加速度検出素子を構成し、上記加速度検出素子が第１と第２の共振子の対向方向の加速度に対して撓み得るように、その長手方向一端部または両端部を固定支持してなり、加速度の印加により上記加速検出素子が撓み、その撓みによって生じる第１と第２の共振子の周波数変化またはインピーダンス変化を差動的に検出することにより、加速度を検出可能としたことを特徴とする加速度センサ。

【請求項６】上記第１，第２の共振子は、その長さ方向中央部にエネルギーが閉じ込められる振動モード素子であり、ベース板と第１，第２の共振子との間に、共振子の閉じ込め振動の範囲より広くかつ加速度によって撓む範囲より小さい空隙が形成されていることを特徴とする請求項５に記載の加速度センサ。

【請求項７】上記加速度検出素子の加速度印加方向の外側面が、ケース部材によって覆われ、かつ加速度検出素子とケース部材とで形成される開放面がカバー部材によって覆われ、第１と第２の共振子に形成された電極は、ケース部材の表面に形成された内部電極を介してカバー部材の表面に形成された外部電極に接続されていることを特徴とする請求項５または６に記載の加速度センサ。

【請求項８】上記第１と第２の共振子をそれぞれの周波数で発振させ、各発振周波数差を検出し、この周波数差から加速度に比例した信号を得ることを特徴とする請求項１ないし７のいずれかに記載の加速度センサ。

【請求項９】上記第１と第２の共振子を同一周波数で発振させ、各共振子の電気的インピーダンスの違いから位相差または振幅差を検知し、これら位相差または振幅差から加速度に比例した信号を得ることを特徴とする請求項１ないし７のいずれかに記載の加速度センサ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は加速度センサに関するものである。

【０００２】

【従来の技術】従来、圧電セラミックスを利用した加速度センサとして、例えば特許第２７８０５９４号公報に記載のものが知られている。この加速度センサは、一対の圧電セラミックスよりなる圧電素子を対面接合して一体化したバイモルフ型検出素子を備え、この素子をケース内に両持ち梁構造で収納支持してある。この加速度センサに加速度が加わると、検出素子が撓むことによって圧電素子に応力が発生し、圧電効果によって発生した電荷または電圧を検知して、加速度を知ることができる。この加速度センサの場合には、小型で、表面実装型部品（チップ部品）に容易に構成できるという利点がある。

【０００３】この原理の加速度センサの場合には、回路を構成する際、回路から流れ込むバイアス電流が圧電体の容量Ｃにチャージされ、回路が飽和してしまうので、バイアス電流をリークさせるための抵抗Ｒが必要となる。ところが、抵抗Ｒと容量Ｃとによってハイパスフィルタが構成され、カットオフ以下の周波数であるＤＣや低周波の加速度を検出できない。

【０００４】

【発明が解決しようとする課題】一方、座屈音叉構造の支持体に２個の振動子を取り付け、加速度が印加されると、中央にある慣性部（重り）により２つの音叉構造部分に取り付けられた振動子は引張と圧縮の応力を受け、２つの振動子に生じる周波数差によって加速度を検出する加速度センサも知られている（例えば特開平４－３６１１６５号公報）。この場合には、ＤＣや低周波の加速度でも検出可能である。

【０００５】しかしながら、この構造の加速度センサでは、支持体が音叉構造を有するため、構造が複雑で大型であり、各振動子からの電極の引出も煩雑である。そのため、回路基板などに直接実装できる小型の表面実装型部品（チップ部品）に構成することが難しいという問題があった。また、振動子をねじれ振動モードと屈曲振動モードとが結合した振動モードで振動する双音叉型振動子として構成することにより、バイアス周波数の温度依存性を低減しているが、温度依存性を完全には解消できない。

【０００６】そこで、本発明の目的は、小型で表面実装型に構成でき、しかも温度変化などの加速度以外の要因による影響を排除しうる、高感度の加速度センサを提供することにある。

【０００７】

【課題を解決するための手段】上記目的は、請求項１，５に記載の発明によって達成される。すなわち、請求項１に係る発明は、両主面に電極が形成された圧電体よりなり、それぞれ独立した周波数で共振する第１と第２の共振子と、第１と第２のベース板とを備え、第１の共振子を第１のベース板の一面に接合して第１のユニモルフ型加速度検出素子を構成するとともに、第２の共振子を第２のベース板の一面に接合して第２のユニモルフ型加速度検出素子を構成し、第１と第２の加速度検出素子を、第１と第２の共振子が互いに相反方向または対向方向を向き、かつ加速度の印加によってそれぞれ独立して撓み得るように、長手方向一端部または両端部を固定支持してなり、加速度の印加により２つの加速検出素子が独立して撓み、その撓みによって生じる第１と第２の共振子の周波数変化またはインピーダンス変化を差動的に検出することにより、加速度を検出可能としたことを特徴とする加速度センサを提供する。また、請求項５に係る発明は、単一のベース板の表裏面に、両主面に電極が形成された圧電体よりなる第１と第２の共振子を接合して加速度検出素子を構成し、上記加速度検出素子が第１と第２の共振子の対向方向の加速度に対して撓み得るように、その長手方向一端部または両端部を固定支持してなり、加速度の印加により上記加速検出素子が撓み、その撓みによって生じる第１と第２の共振子の周波数変化またはインピーダンス変化を差動的に検出することにより、加速度を検出可能としたことを特徴とする加速度センサを提供する。

【０００８】請求項１では、加速度検出素子を共振子とベース板とを接合したユニモルフ構造としたので、加速度が加わった際に生じる加速度検出素子の撓み変形から、共振子に必要な圧縮または引張応力を効率的に発生させることができる。しかも、一対の加速度検出素子は、その共振子が互いに相反方向または対向方向を向くように連結されるので、一方の検出素子が引張応力を検出すれば、他方の検出素子は圧縮応力を検出することになる。そのため、引張側の共振子の周波数は低くなり、圧縮側の共振子の周波数は高くなる。そこで、両共振子の周波数変化またはインピーダンス変化を差動的に取り出せば、加速度を検出することができる。特に、２つの共振子の周波数変化またはインピーダンス変化を個別に取り出すのではなく、その周波数差またはインピーダンス差を差動的に検出するので、２つの共振子に共通に加わる応力（例えば温度変化による応力）は相殺され、温度変化などの影響を受けない高感度の加速度センサを得ることができる。

【０００９】請求項２のように、第１，第２の加速度検出素子を、加速度の作用に伴う曲げ中性面が、共振子とベース板との接合面またはベース板側になるように設定するのがよい。つまり、中性面が共振子側にあると、１つの共振子の内部で圧縮応力と引張応力が発生することになり、出力信号が小さくなるからである。なお、曲げ中性面を共振子とベース板との接合面またはベース板側とするには、例えばベース板の曲げ剛性を共振子と同等またはそれより大きくすればよい。

【００１０】請求項３のように、第１，第２の共振子を、その長さ方向中央部にエネルギーが閉じ込められる振動モード素子とし、第１，第２のベース板と第１，第２の共振子との間に、共振子の閉じ込め振動の範囲より広くかつ加速度によって撓む範囲より小さい空隙を形成するのがよい。共振子とベース板とを全面で対面接合してもよいが、この場合には共振子の振動がベース板で拘束されるので、共振子としての性能（ＱおよびＫ）が低下するからである。なお、共振子とベース板とを全面で対面接合した場合には、共振子としての性能は低下するが、逆に加速度による応力の発生効率の面では効果的である。

【００１１】請求項４のように、第１と第２の加速度検出素子の長手方向両端部をスペーサ層を介して対面接合し、第１と第２の加速度検出素子の加速度印加方向の外側面をケース部材によって覆い、第１と第２の加速度検出素子とケース部材とで形成される開放面をカバー部材によって覆い、第１と第２の共振子に形成された電極を、ケース部材の表面に形成された内部電極を介してカバー部材の表面に形成された外部電極に接続するのが望ましい。この場合には、加速度検出素子の周囲をケース部材およびカバー部材によって完全に包囲でき、しかも表面実装型電子部品に構成できる利点がある。

【００１２】請求項５では、請求項１のようにユニモルフ構造の２個の加速度検出素子を用いるのに代えて、単一のベース板の表裏面にそれぞれ共振子を接合してバイモルフ構造の加速度検出素子としたものである。この場合には、ベース板として比較的撓みやすい材料を用いても、曲げ中性面（応力が０の面）をベース板内に設定することができるので、ベース板の表裏面に設けられた共振子に引張応力と圧縮応力とを効果的に発生させること

ができる。そのため、両共振子の周波数変化またはインピーダンス変化を差動的に検出することにより、加速度を検出することができる。また、ベース板が単一であるため、ベース板の厚み方向の寸法を短縮でき、加速度センサを小型に構成できる。なお、請求項６および７は、それぞれ請求項３および４と同様の効果を有する。

【００１３】第１の共振子と第２の共振子とから得られる信号を差動的に取り出し、加速度検出素子に作用する加速度に比例した信号を得る方法としては、請求項８のように、第１と第２の共振子をそれぞれの周波数で発振させ、各発振周波数差を検出し、この周波数差から加速度に比例した信号を得る方法と、請求項９のように、第１と第２の共振子を同一周波数で発振させ、各共振子の電気的インピーダンスの違いから位相差または振幅差を検知し、これら位相差または振幅差から加速度に比例した信号を得る方法とがある。いずれの方法を用いても、加速度を高精度に検出することができる。

【００１４】

【発明の実施の形態】図１～図５は本発明にかかる加速度センサの第１実施例を示す。この加速度センサ１Ａは、２個の加速度検出素子２，３を絶縁性セラミック等からなる絶縁ケース５，６内に両持ち梁構造で収納支持したものである。この実施例の加速度検出素子２，３はユニモルフ型検出素子であり、短冊形状の圧電セラミック板の表裏両主面にそれぞれ電極２１，２２および３１，３２を形成した共振子２０，３０を、それぞれベース板２３，３３の一面に接着やはんだ付け等により接合することにより一体化したものである。この実施例の共振子２０，３０は、共にエネルギー閉じ込め型厚みすべり振動モードの共振子であり、共振子２０，３０の長さ方向に分極されている。表裏面の電極２１，２２および３１，３２は、一端部が共振子２０，３０の中央部で対向し、他端部が共振子２０，３０の異なる端部へ引き出されている。

【００１５】ベース板２３，３３は共振子２０，３０と同一長さ、同一幅に形成された絶縁板であり、ユニモルフ型加速度検出素子２，３の加速度の作用に伴う曲げ中性面（図５に破線Ｎ１，Ｎ２で示す）が、共振子２０，３０とベース板２３，３３との接合面よりベース板２３，３３側になるように設定されている。ベース板２３，３３は、共振子２０，３０より曲げ剛性の高い材料で構成されたものが望ましく、質量体（重り）として機能させるため質量ができるだけ大きいものが望ましい。ベース板２３，３３の共振子２０，３０との対向面には、共振子２０，３０の閉じ込め振動の範囲より広くかつ加速度によって撓む範囲より小さい空隙を形成するための凹部２３ａ，３３ａが形成されている。これにより、共振子２０，３０の閉じ込め振動を拘束せず、かつ加速度によって共振子２０，３０とベース板２３，３３とが一体に撓むことができる。

【００１６】なお、凹部２３ａ，３３ａは共振子２０，３０の振動を妨げないように振動空間を形成するためのものであり、振幅は微少であるから、凹部２３ａ，３３ａに代えて、共振子２０，３０とベース板２３，３３とを接合する接着剤層の厚みによって、空隙を形成することも可能である。

【００１７】２個のユニモルフ型加速度検出素子２，３は、共振子２０，３０が互いに相反方向を向き、かつ加速度Ｇの印加方向にそれぞれ独立して撓み得るように、長手方向両端部がスペーサ層である接着層４を介して対面接合されている。そのため、加速度検出素子２，３の中央部の間には、所定の隙間が設けられている。加速度検出素子２，３の加速度Ｇの印加方向の外側面は、左右一対のケース部材５，５によって覆われている。ケース部材５はコ字形断面形状に形成されており、その両端突出部５ａが加速度検出素子２，３の両端部外側面（共振子２０，３０の露出面）に接着固定されている。そのため、ケース部材５と加速度検出素子２，３との間には、ケース部材５の凹部５ｂによって、加速度Ｇに伴い加速度検出素子２，３が撓み得る空間が形成されている。また、加速度検出素子２，３とケース部材５とで形成される上下の開放面が上下一対のカバー部材６，６によって覆われている。カバー部材６の内面には、加速度検出素子２，３との接触を防止するための空洞形成用凹部６ａが形成され、その外周部が開放面に接着固定されている。そのため、加速度検出素子２，３の加速度Ｇによる変位部分は、ケース部材５およびカバー部材６によって完全に密閉されている。なお、加速度検出素子２，３を、共振子２０，３０が相反方向を向くように接着層４を介して接合したが、これとは逆に、共振子２０，３０が対向方向を向くように接合してもよい。この場合には、加速度Ｇの印加による引張側の共振子と圧縮側の共振子とが逆になる。

【００１８】この実施例では、ケース部材５として断面コ字形の部材を用いたが、ケース５と加速度検出素子２，３との間に設けられる接着剤層の厚みによって撓み空間を形成すれば、ケース部材５として平板状の部材を用いることも可能である。特に、加速度Ｇによる検出素子２，３の撓み量は微少であるから、接着剤層の厚みでも十分な空間を形成できる。同様に、カバー部材６の内面に枠形に設けられる接着剤層の厚みによって空洞を形成できるので、カバー部材６の内面の空洞形成用凹部６ａも省略可能である。

【００１９】上記ベース板２３，３３、ケース部材５およびカバー部材６は共に絶縁材料で形成されている。具体的には、セラミック板や樹脂板を用いることができる。なお、ベース板２３，３３は必ずしも絶縁材料に限定されるものではなく、金属材料を用いることも可能である。

【００２０】共振子２０，３０に形成された電極２１，

２２および３１，３２のうち、電極２１，３２は、加速度検出素子２，３とケース部材５とで形成される開放面に設けられた帯状の内部電極５１によって互いに導通し、かつケース部材５の外側面まで引き出されている。また、電極２２は上側の開放面に形成された内部電極５２によってケース部材５の外側面まで引き出され、電極３１は下側の開放面に形成された内部電極５３によってケース部材５の異なる外側面まで引き出されている。

【００２１】ケース部材５およびカバー部材６の外表面には、図１に示すように、外部電極６１，６２，６３が形成されており、上記内部電極５１，５２，５３は、それぞれ外部電極６１，６２，６３に接続されている。これによって、表面実装型のチップ型加速度センサを得ることができる。

【００２２】なお、この実施例では、加速度検出素子２（共振子２０）の一方の電極２１と、加速度検出素子３（共振子３０）の一方の電極３２とを内部電極５１によって相互に接続し、共通電極としたが、４個の電極２１，２２および３１，３２をそれぞれ独立して外部電極に引き出してもよい。この場合には、内部電極および外部電極もそれぞれ４個設けられる。図４はこの加速度センサ１Ａを回路基板ＰＣＢの回路パターンＰａに実装した状態を示す。

【００２３】上記構成よりなる加速度センサ１Ａの製造方法を図６に示す。まず、表裏面に電極２１，２２および３１，３２となる電極パターンが形成された共振子２０，３０用の２枚の圧電セラミック親基板に、ベース板２３，３３用の２枚の親ベース板がそれぞれ接合された加速度検出素子の親基板２Ｍ，３Ｍと、内面側の所定位置ごとに所定幅の凹溝５ｂが形成されたケース部材５用の一対の親ケース部材５Ｍとを準備し、上記親基板２Ｍ，３Ｍ，５Ｍを接着剤などを介して一体に接合する。こうして接合した接合体を上下方向に複数枚積層してブロックＢ１（図６の（ａ）参照）を得る。このブロックＢ１を図６の（ａ）の切断線Ｓでカットし、複数の個別ブロックＢ２を得る（図６の（ｂ）参照）。

【００２４】カットされた個別ブロックＢ２を横倒しにし、その上下面に、図６の（ｃ）のように、内面側に多数の空洞形成用凹部６ａを有する親カバー部材６Ｍを接合し、ブロックを得る。なお、親カバー部材６Ｍの外面には、予め外部電極となる電極パターンが形成されている。このブロックを縦横にカットしてセンサ素子を構成し、カットされたセンサ素子に対して、側面および端面の電極をスパッタなどによって形成することで、図１に示す加速度センサ１Ａを得る。上記のように夫々の部材を親基板で準備し、親基板の状態で積層接着することができるので、量産性が高く、均質で、安価な加速度センサ１Ａを得ることができる。

【００２５】図７は加速度センサの第２実施例を示す。この加速度センサ１Ｂは、ベース板２３，３３を凹部を有しない平板状材料とし、これらベース板２３，３３の表面に共振子２０，３０をそれぞれ対面接着して２つの加速度検出素子２’，３’を構成したものである。加速度検出素子２’，３’の長手方向両端部は接着剤層４を介して相互に接着され、断面コ字形の一対のケース部材５，５によって外側から固定支持されている。なお、上下の開放面には図２と同様なカバー部材６（図示せず）が接着される。

【００２６】第１実施例では、ベース板２３，３３の共振子２０，３０との対向面に、共振子２０，３０の閉じ込め振動の範囲より広くかつ加速度によって撓む範囲より小さい空隙形成用の凹部２３ａ，３３ａを形成したが、凹部２３ａ，３３ａを設けた部分では共振子２０，３０が単体で撓むので、その表裏面が引張面と圧縮面とになり、必ずしも大きな出力を得ることができないことがある。そこで、第２実施例では、ベース板２３，３３と共振子２０，３０とを全面で対面接着することにより、加速度Ｇによってベース板２３，３３と共振子２０，３０とを一体に撓めることができ、応力を効果的に発生させて大きな出力を得るようにしたものである。ただし、この場合には、ベース板２３，３３によって共振子２０，３０の閉じ込め振動が拘束されるので、共振子としての性能（Ｑ，Ｋ）は若干低下する可能性がある。

【００２７】図８は加速度センサの第３実施例を示す。この加速度センサ１Ｃは、単一のベース板８の表裏面に、両主面に電極２１，２２および３１，３２が形成された圧電セラミック板よりなる共振子２０，３０を接合して加速度検出素子７を構成したものである。加速度検出素子７の長手方向両端部は、図２と同様に、一対の断面コ字形ケース部材５によって左右両側から固定支持され、さらに表裏の開放面にカバー部材６（図示せず）が固定される。

【００２８】この実施例の共振子２０，３０も、第１実施例と同様に、エネルギー閉じ込め形の厚みすべり振動モード素子である。ベース板８の表裏面には、共振子２０，３０との間に、共振子２０，３０の閉じ込め振動の範囲より広くかつ加速度によって撓む範囲より小さい空隙形成用の凹部８１，８２が形成されている。なお、ベース板８の凹部８１，８２は必須ではなく、共振子２０，３０をその中央部を除く部分でベース板８と接着してもよく、あるいは全面で接着してもよい。

【００２９】この実施例では、１枚のベース板８の表裏面に共振子２０，３０を接合したので、曲げ撓みの中性面Ｎ３は、図８に破線で示すように、ベース板８の板厚の中心部にある。そのため、加速度Ｇが印加された場合に、ベース板８は質量体として機能し、一方の共振子２０に引張応力、他方の共振子３０に圧縮応力を効果的に発生させることができる。そのため、加速度Ｇの印加に応じた大きな周波数差またはインピーダンス差を得ることができる。また、第１実施例のように、２枚のユニモ

ルフ型検出素子２，３を用いるものに比べて、ベース板８が１枚で足りるので、幅寸法Ｄを短縮することができ、より小型の加速度センサを実現できる。

【００３０】図９は上記加速度センサ１Ａを用いた加速度検出装置の一例を示す。この検出装置は加速度検出素子２，３の独立発振を利用したものであり、加速度センサ１Ａの外部電極６２と６１が発振回路９ａに接続され、外部電極６３と６１が発振回路９ｂに接続されている。発振回路９ａ，９ｂとしては、例えば公知のコルピッツ型発振回路などを使用できる。共振子２０，３０を発振回路９ａ，９ｂによってそれぞれ独自に発振させ、その発振周波数 f_1 ， f_2 が周波数差カウンタ９ｃに入力され、その周波数差に比例した信号 V_0 を出力する。

【００３１】加速度センサ１Ａに加速度Ｇが印加されていない状態では、２個の共振子２０，３０は独立した共振子として一定の周波数で発振している。これら共振子２０，３０が全く同一構造であれば、同じ周波数で発振するので、周波数差カウンタ９ｃの出力信号 V_0 は零である。一方、加速度センサ１Ａに加速度Ｇが加わると、検出素子２，３には加速度の印加方向と逆方向の慣性力が作用し、検出素子２，３の中央部分が加速度Ｇの印加方向と逆方向に撓む。検出素子２，３の撓みに伴って発生する応力によって、図５の例では、一方の共振子２０には引張応力が作用し、他方の共振子３０には圧縮応力が作用する。厚みすべり振動モードを利用した共振子の場合、引張応力の共振子２０の発振周波数は低下し、圧縮応力の共振子３０の発振周波数は上昇する。その周波数差を電極２１，２２および３１，３２から内部電極５１，５２，５３を介して外部電極６１，６２，６３へと取り出すことによって、加速度Ｇに比例した信号 V_0 を得ることができる。なお、信号 V_0 によって、加速度Ｇの大きさだけでなく、加速度Ｇの方向も検出することができる。

【００３２】加速度センサ１Ａを温度変化がある環境で使用すると、共振子２０，３０、ベース板２３，３３、ケース部材５、カバー部材６が熱膨張を起こす。共振子２０，３０とベース板２３，３３の熱膨張係数が異なる場合には、温度変化によって検出素子２，３に撓みが発生し、共振子２０，３０に応力が発生する。同様に、検出素子２，３とケース部材５、カバー部材６との熱膨張係数が異なる場合も、温度変化によって検出素子２，３に応力が作用する。その結果、加速度以外の要因で周波数差に変化が生じることになる。しかしながら、共振子２０，３０が互いに同一材料，同一形状に形成され、かつベース板２３，３３が同一材料，同一形状に形成されておれば、温度変化に伴う応力も同一となる。そのため、周波数差カウンタ９ｃで２個の共振子２０，３０の出力を差動的に取り出すことにより、各共振子２０，３０が同一に受ける温度変化などによる出力信号の変化を相殺することができる。したがって、加速度Ｇに対してのみ感度を持つ加速度検出装置を得ることができる。

【００３３】図１０は上記加速度センサ１Ａを用いた加速度検出装置の他の例を示す。この検出装置は加速度検出素子２，３の単一発振を利用したものである。加速度センサ１Ａの外部電極６２と６３はインピーダンス差動検出回路９ｄに接続され、共通電極である外部電極６１は発振回路９ｅに接続されている。なお、９ｆ９ｇはマッチング用抵抗である。この場合には、両方の共振子２０，３０を発振回路９ｅによって同一の周波数で発振させ、それぞれの共振子２０，３０の電気的インピーダンスの違いから、位相差または振幅差を検知し、加速度Ｇに比例した出力 V_0 をインピーダンス差動検出回路９ｄから取り出すものである。同一周波数で発振させるには、どちらか一方の共振子の出力、または両方の共振子の合算された出力をフィードバックして発振回路９ｅを構成すればよい。この場合も、図９の例と同様に、加速度Ｇに比例した信号を取り出すことができるとともに、温度変化等による出力変化を相殺できるので、加速度Ｇに対してのみ感度を持つ加速度検出装置を得ることができる。

【００３４】図９および図１０の加速度検出装置では、加速度センサとして第１実施例の加速度センサ１Ａを用いたが、図７，図８に示す他の加速度センサ１Ｂ，１Ｃでも同様に使用できる。上記実施例の加速度センサ１Ａ～１Ｃは、いずれも検出素子の両端部がケース部材によって固定支持された構造のものを示したが、一端部のみがケース部材によって固定支持されたもの、つまり片持ち梁構造としてもよい。この場合には、加速度の印加に伴う自由端の変位量が大きいので、大きな周波数変化またはインピーダンス変化を得ることが可能である。また、第１～第３実施例の加速度センサ１Ａ，１Ｂ，１Ｃでは、共振子２０，３０として厚みすべり振動モードの共振子を用いたが、これに限るものではなく、他の振動モード（例えば厚み縦振動モード、長さ振動モード、面積屈曲モードなど）の共振子でも使用可能である。

【００３５】

【発明の効果】以上の説明で明らかなように、請求項１に記載の発明によれば、共振子とベース板とを接合したユニモルフ構造の一対の加速度検出素子を、共振子が互いに相反方向または対向方向を向くように連結したので、加速度が加わった際に生じる加速度検出素子の撓み変形から、一方の共振子に圧縮応力を、他方の共振子に引張応力を効率的に発生させることができる。したがって、両方の共振子の周波数変化またはインピーダンス変化を差動的に取り出すことによって、加速度に比例した信号を得ることができ、検出感度のよい加速度センサを実現できる。また、周波数変化またはインピーダンス変化を用いて加速度を検出するので、ＤＣや低周波の加速度でも検出可能である。さらに、温度変化などによる応力は両方の共振子に共通に加わるので、両方の共振子の

出力を差動的に取り出すことで、加速度以外の要因による応力を相殺でき、加速度にのみ感度を持つ加速度センサを得ることができる。また、加速度検出素子が簡単な構造であり、電極の引出も容易であるため、小型に構成できるとともに、表面実装型部品（チップ部品）にも容易に構成できる。

【００３６】請求項５に記載の発明によれば、単一のベース板の表裏面に、両主面に電極が形成された圧電体よりなる第１と第２の共振子を接合して加速度検出素子を構成したので、加速度によって共振子の一方に圧縮応力、他方に引張応力を効果的に発生させることができる。そのため、両方の共振子の周波数変化またはインピーダンス変化を差動的に取り出すことによって、加速度に比例した信号を得ることができ、検出感度がよく、しかも加速度に対してのみ感度を持つことが可能な加速度センサを得ることができる。この場合も、請求項１にかかる発明と同様に、温度変化などによる影響を解消でき、かつ小型でチップ型の部品に容易に構成できる。さらに、単一のベース板の両面に共振子を接合する構造であるから、幅寸法を一層短縮することができ、一層小型の加速度センサを実現できる。

【図面の簡単な説明】

【図１】本発明にかかる加速度センサの第１実施例の全体斜視図である。

【図２】図１に示した加速度センサの分解斜視図である。

【図３】図１に示した加速度センサのカバー部材を除いた分解斜視図である。

【図４】図１に示した加速度センサを回路基板に実装した状態の側面図である。

【図５】図４のＶ－Ｖ線断面図である。

【図６】図１に示した加速度センサの製造方法の一例の工程図である。

【図７】本発明にかかる加速度センサの第２実施例のＶ－Ｖ線断面図である。

【図８】本発明にかかる加速度センサの第３実施例のＶ－Ｖ線断面図である。

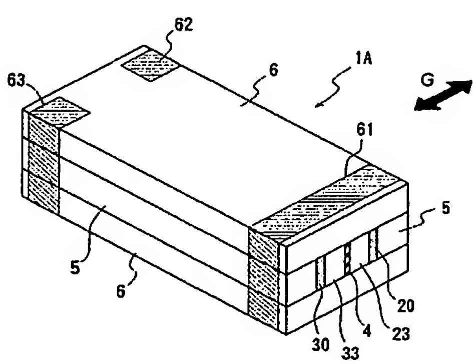
【図９】本発明にかかる加速度センサを用いた加速度検出装置の一例の回路図である。

【図１０】本発明にかかる加速度センサを用いた加速度検出装置の他の例の回路図である。

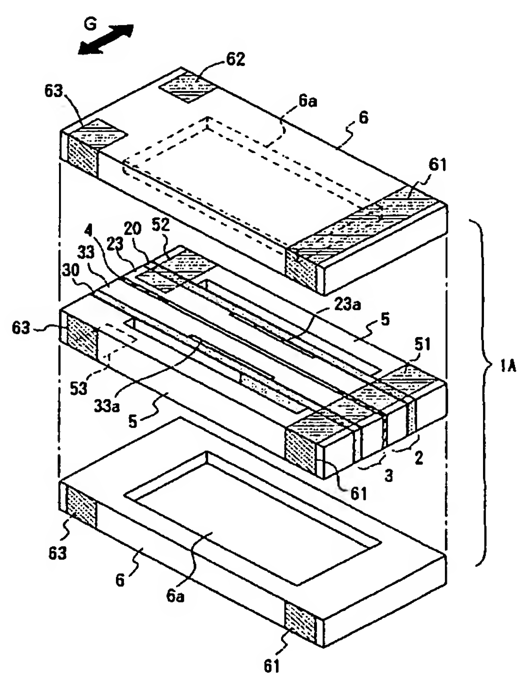
【符号の説明】

１Ａ～１Ｃ	加速度センサ
２，３，２'，３'，７	加速度検出素子
５	ケース部材
６	カバー部材
２０，３０	共振子
２１，２２，３１，３２	電極
２３，３３，８	ベース板
５１～５３	内部電極
６１～６３	外部電極

【図１】



【図２】



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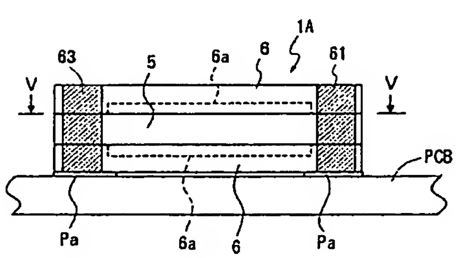
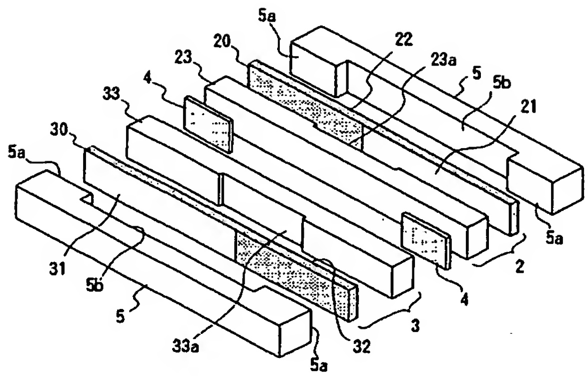


【図３】



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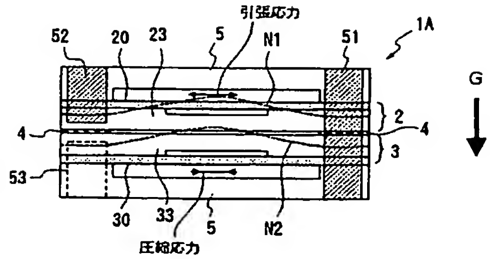
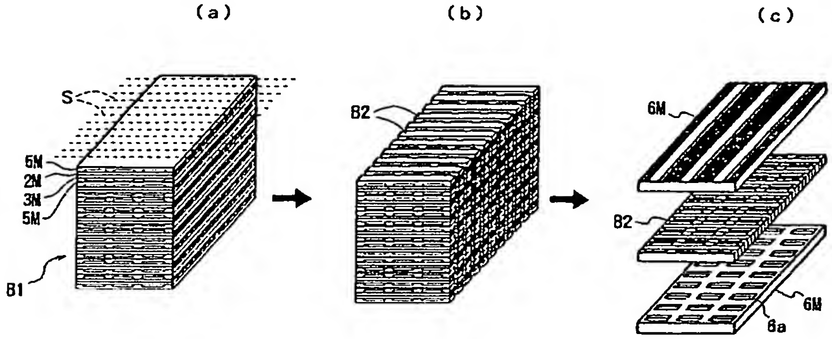
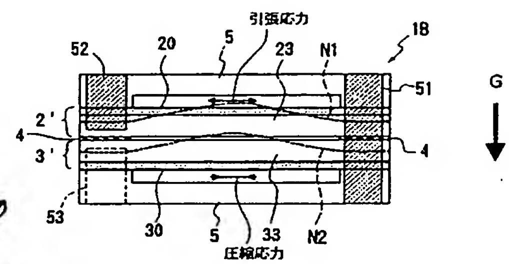


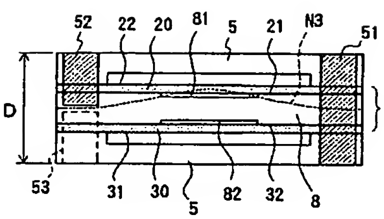
【図６】



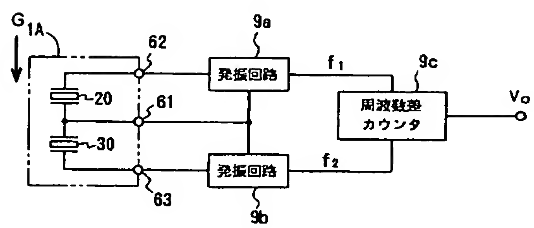
【図７】



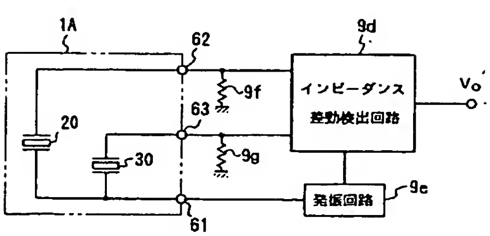
【図８】



【図９】



【図１０】



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CLAIMS

[Claim(s)]
[Claim 1] The 1st and the 2nd resonator which resonate on the frequency which consisted of a piezo electric crystal with which the electrode was formed in both principal planes, and became independent, respectively, While having the 1st and the 2nd base plate, joining the 1st resonator to the whole surface of the 1st base plate and constituting the 1st uni-morph mold acceleration sensing element Join the 2nd resonator to the whole surface of the 2nd base plate, and the 2nd uni-morph mold acceleration sensing element is constituted. The 1st and 2nd acceleration sensing element so that the 1st and the 2nd resonator may turn to the direction of repulsion, or the opposite direction mutually and it may bend independently by impression of acceleration, respectively Come to carry out fixed support of the longitudinal direction end section or the both ends, and two acceleration sensing elements bend independently by impression of acceleration. The acceleration sensor characterized by making acceleration detectable by detecting in differential frequency change or impedance change of the 1st and the 2nd resonator produced by the bending.
[Claim 2] The above 1st and the 2nd acceleration sensing element are an acceleration sensor according to claim 1 characterized by being set up so that the bending neutral side accompanying an operation of acceleration may be on a plane-of-composition [of a resonator and a base plate], or base plate side.
[Claim 3] The 1st and 2nd resonator of the above is an acceleration sensor according to claim 1 or 2 which is the oscillation mode component by which energy is confined in the die-length direction center section, and is characterized by forming the opening smaller than the range which bends with acceleration more widely [a resonator shuts up between the 1st and 2nd base plate and the 1st and 2nd resonator, and] than the range of vibration.

[Claim 4] Confrontation junction of the longitudinal direction both ends of the above 1st and the 2nd acceleration sensing element is carried out through a spacer layer. The lateral surface of the acceleration impression direction of the 1st and 2nd acceleration sensing element is covered with a case member. And the electrode with which the open field formed by the 1st, the 2nd acceleration sensing element, and the case member was covered with the covering member, and was formed in the 1st and the 2nd resonator The acceleration sensor according to claim 1 to 3 characterized by connecting with the external electrode formed in the front face of a covering member through the internal electrode formed in the front face of a case member.
[Claim 5] So that the 1st and the 2nd resonator which consist of a piezo electric crystal with which the electrode was formed in both principal planes may be joined, an acceleration sensing element may be constituted at the single front rear face of a base plate and the above-mentioned acceleration sensing element may bend to the acceleration of the opposite direction of the 1st and the 2nd resonator at it By coming to carry out fixed support of the longitudinal direction end section or both ends, and the above-mentioned acceleration sensing element's bending by impression of acceleration, and detecting in differential frequency change or impedance change of the 1st and the 2nd resonator produced by the bending The acceleration sensor characterized by making acceleration detectable.
[Claim 6] The 1st and 2nd resonator of the above is an acceleration sensor according to claim 5 which is the oscillation mode component by which energy is confined in the die-length direction center section, and is characterized by forming the opening smaller than the range which bends with acceleration more widely [a resonator shuts up between a base plate and the 1st and 2nd resonator, and] than the range of vibration.
[Claim 7] The electrode with which the open field in which the lateral surface of the acceleration impression direction of the above-mentioned acceleration sensing element is covered with a case member, and is formed by the acceleration sensing element and the case member was covered with the covering member, and was formed in the 1st and the 2nd resonator is an acceleration sensor according to claim 5 or 6 characterized by to connect with the external electrode formed in the front face of a covering member through the internal electrode formed in the front face of a case member.
[Claim 8] The acceleration sensor according to claim 1 to 7 characterized by acquiring the signal which was made to oscillate the

above 1st and the 2nd resonator on each frequency, detected each oscillation delta frequency, and is proportional to acceleration from this delta frequency.

[Claim 9] The acceleration sensor according to claim 1 to 7 characterized by acquiring the signal which was made to oscillate the above 1st and the 2nd resonator on the same frequency, detected phase contrast or an amplitude difference from the difference in the electric impedance of each resonator, and is proportional to acceleration from these phase contrast or an amplitude difference.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to an acceleration sensor.

[0002]

[Description of the Prior Art] Conventionally, the thing given in for example, the patent No. 2780594 official report is known as an acceleration sensor using electrostrictive ceramics. This acceleration sensor is equipped with the bimorph mold sensing element which carried out confrontation junction of the piezoelectric device which consists of electrostrictive ceramics of a pair, and was unified, and has carried out receipt support of this component with doubly-supported beam structure into the case. If acceleration joins this acceleration sensor, when a sensing element bends, the charge or electrical potential difference which stress generated in the piezoelectric device and was generated according to the piezo-electric effect can be detected, and acceleration can be known. In the case of this acceleration sensor,

there is an advantage that it is small and can constitute easily in surface mount die parts (chip).

[0003] In the case of the acceleration sensor of this principle, since the bias current which flows in from a circuit is charged by the capacity C of a piezo electric crystal and a circuit is saturated in case a circuit is constituted, the resistance R for making a bias current leak is needed. However, a high-pass filter is constituted by Resistance R and capacity C, and acceleration of DC which is a frequency below a cut-off, or low frequency cannot be detected.

[0004]

[Problem(s) to be Solved by the Invention] On the other hand, if two vibrator is attached in the base material of buckling tuning fork structure and acceleration is impressed, the vibrator attached in the two tuning fork structured divisions by the inertia section (weight) which exists in the center receives the stress of **** and compression, and the acceleration sensor which detects acceleration by the delta frequency produced in two vibrator is also known (for example, JP,4-361165,A). In this case, it is detectable also with the acceleration of DC or low frequency.

[0005] However, in the acceleration sensor of this structure, since a base material has tuning fork structure, structure is complicated, and is large-sized and the drawer of the electrode from each vibrator is also complicated. Therefore, there was a problem that it was difficult for the circuit board etc. to constitute in the small surface mount die parts (chip) which can carry out direct mounting. Moreover, temperature dependence is completely uncancelable although the temperature dependence of a bias frequency is reduced by constituting as congruence tuning fork mold vibrator which vibrates by the oscillation mode with which torsional-vibration mode and the crookedness oscillation mode combined vibrator.

[0006] Then, the purpose of this invention is to offer the acceleration sensor of high sensitivity which is small, can constitute in a surface mount mold, and can moreover eliminate the effect by factors other than acceleration, such as a temperature change.

[0007]

[Means for Solving the Problem] The above-mentioned purpose is attained by invention of a publication at claims 1 and 5. Namely, the 1st and the 2nd resonator which resonate on the frequency which invention concerning claim 1 consisted of a piezo electric crystal with which the electrode was formed in both principal planes, and became independent, respectively, While having the 1st and the 2nd base plate, joining the

1st resonator to the whole surface of the 1st base plate and constituting the 1st uni-morph mold acceleration sensing element Join the 2nd resonator to the whole surface of the 2nd base plate, and the 2nd uni-morph mold acceleration sensing element is constituted. The 1st and 2nd acceleration sensing element so that the 1st and the 2nd resonator may turn to the direction of repulsion, or the opposite direction mutually and it may bend independently by impression of acceleration, respectively Come to carry out fixed support of the longitudinal direction end section or the both ends, and two acceleration sensing elements bend independently by impression of acceleration. By detecting in differential frequency change or impedance change of the 1st and the 2nd resonator produced by the bending, the acceleration sensor characterized by making acceleration detectable is offered. Moreover, at the single front rear face of a base plate, invention concerning claim 5 joins the 1st and the 2nd resonator which consist of a piezo electric crystal with which the electrode was formed in both principal planes, and constitutes an acceleration sensing element. So that the above-mentioned acceleration sensing element may bend to the acceleration of the opposite direction of the 1st and the 2nd resonator By coming to carry out fixed support of the longitudinal direction end section or both ends, and the above-mentioned acceleration sensing element's bending by impression of acceleration, and detecting in differential frequency change or impedance change of the 1st and the 2nd resonator produced by the bending The acceleration sensor characterized by making acceleration detectable is offered.

[0008] In claim 1, since the acceleration sensing element was made into the uni-morph structure which joined the resonator and the base plate, compression or tensile stress required for a resonator can be efficiently generated from bending deformation of the acceleration sensing element produced when acceleration is added. And since the acceleration sensing element of a pair is connected so that the resonator may turn to the direction of repulsion, or the opposite direction mutually, as for the sensing element of another side, compressive stress will be detected if one sensing element detects tensile stress. Therefore, the frequency of the resonator of the tension side becomes low and the frequency of the resonator by the side of compression becomes high. Then, acceleration is detectable if frequency change or impedance change of both resonators is taken out in differential. Especially the stress (for example, stress by the temperature change) added common to two resonators since frequency change or impedance change of two resonators is not taken out according

to an individual but the delta frequency or an impedance difference is detected in differential is offset, and the acceleration sensor of the high sensitivity which is not influenced of a temperature change etc. can be obtained.

[0009] It is good to set up the 1st and 2nd acceleration sensing element like claim 2, so that the bending neutral side accompanying an operation of acceleration may be on a plane-of-composition [of a resonator and a base plate], or base plate side. That is, it is because compressive stress and tensile stress will occur inside one resonator and an output signal will become small, if a neutral side is in a resonator side. In addition, what is necessary is just to make flexural rigidity of a base plate larger than a resonator, an EQC, or it, in order to make a bending neutral side into a plane-of-composition [of a resonator and a base plate], or base plate side.

[0010] It is good to form an opening smaller than the range which bends with acceleration more widely [use the 1st and 2nd resonator as the oscillation mode component by which energy is confined in the die-length direction center section like claim 3, and a resonator shuts up between the 1st and 2nd base plate and the 1st and 2nd resonator, and] than the range of vibration. Although confrontation junction of a resonator and the base plate may be carried out on the whole surface, it is because vibration of a resonator is restrained with a base plate in this case, so the engine performance (Q and K) as a resonator falls. In addition, when confrontation junction of a resonator and the base plate is carried out on the whole surface, although the engine performance as a resonator falls, it is conversely effective in respect of the generating effectiveness of the stress by acceleration.

[0011] Confrontation junction of the longitudinal direction both ends of the 1st and 2nd acceleration sensing element is carried out through a spacer layer like claim 4. The lateral surface of the acceleration impression direction of the 1st and 2nd acceleration sensing element is covered by the case member. It is desirable to cover the open field formed by the 1st, the 2nd acceleration sensing element, and the case member by the covering member, and to connect the electrode formed in the 1st and the 2nd resonator to the external electrode formed in the front face of a covering member through the internal electrode formed in the front face of a case member. In this case, there is an advantage which can surround the perimeter of an acceleration sensing element completely by the case member and the covering member, and can moreover constitute it in surface mount mold electronic parts.

[0012] In claim 5, it replaces with using two acceleration sensing

elements of uni-morph structure like claim 1, a resonator is joined to the front rear face of a single base plate, respectively, and it considers as the acceleration sensing element of bimorph structure. In this case, since a bending neutral side (stress is the field of 0) can be set up in a **-SU plate even if it uses the ingredient which is comparatively easy to bend as a base plate, the resonator prepared in the front rear face of a base plate can be made to generate tensile stress and compressive stress effectively. Therefore, acceleration is detectable by detecting frequency change or impedance change of both resonators in differential. Moreover, since the base plate is single, the dimension of the thickness direction of a base plate can be shortened and an acceleration sensor can be constituted small. In addition, claims 6 and 7 have the respectively same effectiveness as claims 3 and 4.

[0013] As an approach of acquiring the signal proportional to the acceleration which takes out in differential the signal acquired from the 1st resonator and 2nd resonator, and acts on an acceleration sensing element Like the approach of acquiring the signal which was made oscillating the 1st and the 2nd resonator on each frequency, detected each oscillation delta frequency like claim 8, and is proportional to acceleration from this delta frequency, and claim 9 The 1st and the 2nd resonator are oscillated on the same frequency, phase contrast or an amplitude difference is detected from the difference in the electric impedance of each resonator, and there is a method of acquiring the signal proportional to acceleration from these phase contrast or an amplitude difference. Even if it uses which approach, acceleration is detectable with high precision.

[0014]

[Embodiment of the Invention] Drawing 1 - drawing 5 show the 1st example of the acceleration sensor concerning this invention. This acceleration-sensor 1A carries out receipt support of the two acceleration sensing elements 2 and 3 with doubly-supported beam structure into the insulating case 5 which consists of an insulating ceramic etc., and 6. The acceleration sensing elements 2 and 3 of this example are uni-morph mold sensing elements, and unify the resonators 20 and 30 which formed electrodes 21 and 22, and 31 and 32 in the front **** principal plane of a rectangular piezo-electric ceramic plate, respectively by joining to the whole surface of the base plates 23 and 33 with adhesion, soldering, etc., respectively. Both the resonators 20 and 30 of this example are resonators of the energy ****** type thickness skid oscillation mode, and polarization is carried out in the die-length direction of

resonators 20 and 30. The end section counters in the center section of resonators 20 and 30, and, as for the electrodes 21 and 22 on the rear face of front, and 31 and 32, the other end is pulled out to a different edge of resonators 20 and 30.

[0015] The base plates 23 and 33 are electric insulating plates formed in the same die length as resonators 20 and 30, and the same width of face, and they are set up so that the bending neutral side (broken lines N1 and N2 show to drawing 5) accompanying an operation of the acceleration of the uni-morph mold acceleration sensing elements 2 and 3 may be from the plane of composition of resonators 20 and 30 and the base plates 23 and 33 on base plate 23 and 33 side. What consisted of ingredients with flexural rigidity higher than resonators 20 and 30 is desirable, and since the base plates 23 and 33 are operated as a mass object (weight), what has as large mass as possible is desirable. Resonators 20 and 30 shut up in an opposed face with the resonators 20 and 30 of the base plates 23 and 33, and the crevices 23a and 33a for forming an opening smaller than the range which bends with acceleration more widely than the range of vibration are formed in it. By this, resonators 20 and 30 can shut up, and vibration cannot be restrained, and resonators 20 and 30 and the base plates 23 and 33 can bend in one with acceleration.

[0016] In addition, Crevices 23a and 33a are for forming oscillating space, as vibration of resonators 20 and 30 is not barred, and since the amplitude is very small, it is also possible to replace with Crevices 23a and 33a, and to form an opening with the thickness of the adhesives layer which joins resonators 20 and 30 and the base plates 23 and 33.

[0017] Confrontation junction of the longitudinal direction both ends is carried out through the glue line 4 which is a spacer layer so that resonators 20 and 30 may turn to the direction of repulsion mutually and two uni-morph mold acceleration sensing elements 2 and 3 may bend independently in the impression direction of acceleration G, respectively. Therefore, the predetermined clearance is prepared between the center sections of the acceleration sensing elements 2 and 3. The lateral surface of the impression direction of the acceleration G of the acceleration sensing elements 2 and 3 is covered with the case members 5 and 5 of a right-and-left pair. The case member 5 is formed in the KO typeface cross-section configuration, and adhesion immobilization of the both-ends lobe 5a is carried out at the both-ends lateral surface (exposure of resonators 20 and 30) of the acceleration sensing elements 2 and 3. Therefore, between the case member 5 and the acceleration sensing elements 2 and 3, the space where the acceleration sensing

elements 2 and 3 may bend in connection with acceleration G by crevice 5b of the case member 5 is formed. Moreover, the open field of the upper and lower sides formed by the acceleration sensing elements 2 and 3 and the case member 5 is covered with the covering members 6 and 6 of a vertical pair. Crevice 6a for porosi for preventing contact to the acceleration sensing elements 2 and 3 is formed in the inside of the covering member 6, and adhesion immobilization of the periphery section is carried out in the open field. Therefore, the displacement part by the acceleration G of the acceleration sensing elements 2 and 3 is completely sealed by the case member 5 and the covering member 6. In addition, the acceleration sensing elements 2 and 3 were joined through the glue line 4 so that resonators 20 and 30 might turn to the direction of repulsion, but contrary to this, you may join so that resonators 20 and 30 may turn to the opposite direction. In this case, the resonator of the tension side by impression of acceleration G and the resonator by the side of compression become reverse.

[0018] Although the member of a cross-section KO typeface was used as a case member 5 in this example, if it bends with the thickness of the adhesives layer prepared between a case 5 and the acceleration sensing elements 2 and 3 and space is formed, it is also possible to use a plate-like member as a case member 5. Since especially the amount of bending of the sensing elements 2 and 3 by acceleration G is very small, it can form a sufficient room also by the thickness of an adhesives layer. Since similarly a cavity can be formed with the thickness of the adhesives layer prepared in the inside of the covering member 6 at a frame form, crevice 6a for porosi of the inside of the covering member 6 is also omissible.

[0019] Both the above-mentioned base plates 23 and 33, the case member 5, and the covering member 6 are formed by the insulating material. Specifically, a ceramic plate and a resin plate can be used. In addition, it is also possible for the base plates 23 and 33 not to necessarily be limited to an insulating material, and to use a metallic material.

[0020] The electrodes 21 and 22 formed in resonators 20 and 30, and the electrodes 21 and 32 among 31 and 32 flow mutually with the band-like internal electrode 51 prepared in the open field formed by the acceleration sensing elements 2 and 3 and the case member 5, and are pulled out to the lateral surface of the case member 5. Moreover, an electrode 22 is drawn out to the lateral surface of the case member 5 by the internal electrode 52 formed in the upper open field, and the electrode 31 is pulled out to the lateral surface from which the case member 5 differs with the internal electrode 53 formed in the lower open

field.
[0021] As shown in drawing 1 , the external electrodes 61, 62, and 63 are formed in the outside surface of the case member 5 and the covering member 6, and the above-mentioned internal electrodes 51, 52, and 53 are connected to the external electrodes 61, 62, and 63, respectively. By this, the chip mold acceleration sensor of a surface mount mold can be obtained.
[0022] In addition, although it connected mutually and one electrode 21 of the acceleration sensing element 2 (resonator 20) and one electrode 32 of the acceleration sensing element 3 (resonator 30) were used as the common electrode with the internal electrode 51 in this example, four electrodes 21 and 22, and 31 and 32 may be pulled out independently to an external electrode, respectively. In this case, an internal electrode and four external electrodes are also prepared, respectively. Drawing 4 shows the condition of having mounted this acceleration-sensor 1A in the circuit pattern Pa of the circuit board PCB.
[0023] The manufacture approach of acceleration-sensor 1A which consists of the above-mentioned configuration is shown in drawing 6 . To first, the resonator 20 and two piezo-electric ceramic parent substrates for 30 with which the electrode pattern used as electrodes 21 and 22, and 31 and 32 was formed in the front rear face The base plate 23 and the parent substrates 2M and 3M of an acceleration sensing element to which two parent base plates for 33 were joined, respectively, Parent case member 5M of the pair for case member 5 in which concave 5b of predetermined width of face was formed for every predetermined location by the side of an inside are prepared, and the above-mentioned parent substrates 2M, 3M, and 5M are joined to one through adhesives etc. In this way, two or more sheet laminating of the joined zygote is carried out in the vertical direction, and block B1 (refer to (a) of drawing 6) is acquired. This block B1 is omitted with the cutting plane line S of (a) of drawing 6 , and two or more individual block B-2s are obtained (refer to (b) of drawing 6).
[0024] Cut individual block B-2 is pushed on its side, parent covering member 6M which have much crevice 6a for porosi at an inside side as shown in (c) of drawing 6 are joined to the vertical side, and a block is acquired. In addition, the electrode pattern which serves as an external electrode beforehand is formed in the external surface of parent covering member 6M. This block is omitted in all directions, a sensor component is constituted, and acceleration-sensor 1A shown in drawing 1 is obtained by forming the electrode of a side face and an end face by a spatter etc. to the cut sensor component. Since each member

can be prepared with a parent substrate as mentioned above and laminating adhesion can be carried out in the state of a parent substrate, mass-production nature is high and can obtain homogeneous and cheap acceleration sensor 1A.

[0025] Drawing 7 shows the 2nd example of an acceleration sensor. This acceleration-sensor 1B uses the base plates 23 and 33 as the plate-like ingredient which does not have a crevice, carries out confrontation adhesion of the resonators 20 and 30 on the front face of these base plates 23 and 33, respectively, and constitutes two acceleration sensing element 2' and 3'. It pastes up mutually through the adhesives layer 4, and fixed support of the longitudinal direction both ends of acceleration sensing element 2' and 3' is carried out by the case members 5 and 5 of the pair of a cross-section KO typeface from the outside. In addition, the same covering member 6 (not shown) as drawing 2 pastes an up-and-down open field.

[0026] Although the crevices 23a and 33a smaller than the range which bends with acceleration more widely [resonators 20 and 30 shut up in an opposed face with the resonators 20 and 30 of the base plates 23 and 33, and] than the range of vibration for opening formation were formed in the 1st example Since resonators 20 and 30 are alone bent by the part which formed Crevices 23a and 33a, the front rear face turns into ****** and a compression side, and a big output may necessarily be unable to be obtained. So, in the 2nd example, by carrying out confrontation adhesion of the base plates 23 and 33 and the resonators 20 and 30 on the whole surface, the base plates 23 and 33 and resonators 20 and 30 can be stir-fried to one, stress is generated effectively, and a big output is obtained with acceleration G. However, since resonators 20 and 30 shut up and vibration is restrained with the base plates 23 and 33 in this case, the engine performance (Q, K) as a resonator may fall a little.

[0027] Drawing 8 shows the 3rd example of an acceleration sensor. This acceleration-sensor 1C joins the resonators 20 and 30 which consist of a piezo-electric ceramic plate with which electrodes 21 and 22, and 31 and 32 were formed in both principal planes to the single front rear face of the base plate 8, and constitutes the acceleration sensing element 7. Fixed support of the longitudinal direction both ends of the acceleration sensing element 7 is carried out by the cross-section KO typeface case member 5 of a pair from right-and-left both sides like drawing 2 , and the covering member 6 (not shown) is further fixed to the open field of a front flesh side.

[0028] The resonators 20 and 30 of this example as well as the 1st example are thickness skid oscillation mode components of energy ******

type. Resonators 20 and 30 shut up among resonators 20 and 30, and the crevices 81 and 82 smaller than the range which bends with acceleration more widely than the range of vibration for opening formation are formed in the front rear face of the base plate 8. In addition, the crevices 81 and 82 of the base plate 8 may paste up resonators 20 and 30 with the base plate 8 in the part except the center section rather than may be indispensable, or may paste them up on the whole surface.
[0029] In this example, since resonators 20 and 30 were joined to the front rear face of one base plate 8, the neutral side N3 of bending bending is located in the core of the board thickness of the base plate 8, as a broken line shows to drawing 8 . Therefore, when acceleration G is impressed, the base plate 8 can function as a mass object, and can make one resonator 20 generate compressive stress effectively in the resonator 30 of tensile stress and another side. Therefore, the big delta frequency or impedance difference according to impression of acceleration G can be acquired. Moreover, like the 1st example, since one sheet is sufficient for the base plate 8 compared with the thing using the uni-morph mold sensing elements 2 and 3 of two sheets, the width method D can be shortened and a smaller acceleration sensor can be realized.
[0030] Drawing 9 shows an example of acceleration detection equipment which used the above-mentioned acceleration-sensor 1A. This detection equipment uses the independent oscillation of the acceleration sensing elements 2 and 3, the external electrodes 62 and 61 of acceleration-sensor 1A are connected to oscillator-circuit 9a, and the external electrodes 63 and 61 are connected to oscillator-circuit 9b. As oscillator circuits 9a and 9b, the well-known Colpitts mold oscillator circuit etc. can be used, for example. Resonators 20 and 30 are uniquely oscillated by oscillator circuits 9a and 9b, respectively, and it is the oscillation frequency f1 and f2. Signal V0 which was inputted into delta-frequency counter 9c, and is proportional to the delta frequency It outputs.
[0031] In the condition that acceleration G is not impressed to acceleration-sensor 1A, two resonators 20 and 30 are oscillated on the frequency fixed as an independent resonator. If these resonators 20 and 30 are completely the same structures, since it will oscillate on the same frequency, it is the output signal V0 of delta-frequency counter 9c. It is zero. On the other hand, if acceleration G joins acceleration-sensor 1A, the inertial force of the impression direction of acceleration and hard flow will act on sensing elements 2 and 3, and the central part of sensing elements 2 and 3 will bend to the impression

direction and hard flow of acceleration G. With the stress generated in connection with bending of sensing elements 2 and 3, in the example of drawing 5 , tensile stress acts on one resonator 20, and compressive stress acts on the resonator 30 of another side. In the case of the resonator using the thickness skid oscillation mode, the oscillation frequency of the resonator 20 of tensile stress falls, and the oscillation frequency of the resonator 30 of compressive stress rises. Signal V0 which is proportional to acceleration G by taking out the delta frequency to the external electrodes 61, 62, and 63 through 31 and 32 to electrodes 21 and 22 and the internal electrodes 51, 52, and 53 It can obtain. In addition, signal V0 Not only the magnitude of acceleration G but the direction of acceleration G is detectable.

[0032] If acceleration-sensor 1A is used in an environment with a temperature change, resonators 20 and 30, the base plates 23 and 33, the case member 5, and the covering member 6 will cause thermal expansion. When the coefficients of thermal expansion of resonators 20 and 30 and the base plates 23 and 33 differ, by the temperature change, bending occurs in sensing elements 2 and 3, and stress occurs in resonators 20 and 30. Similarly, when the coefficients of thermal expansion of sensing elements 2 and 3, and the case member 5 and the covering member 6 differ, stress acts on sensing elements 2 and 3 by the temperature change. Consequently, change will arise in a delta frequency by factors other than acceleration. However, if resonators 20 and 30 are mutually formed in the same ingredient and the same configuration and the base plates 23 and 33 are formed in the same ingredient and the same configuration, the stress accompanying a temperature change will also become the same. Therefore, each resonators 20 and 30 can offset change of the output signal by the temperature change received identically by taking out the output of two resonators 20 and 30 in differential by delta-frequency counter 9c. Therefore, the acceleration detection equipment which has sensibility only to acceleration G can be obtained.

[0033] Drawing 10 shows other examples of the acceleration detection equipment which used the above-mentioned acceleration-sensor 1A. This detection equipment uses the single oscillation of the acceleration sensing elements 2 and 3. The external electrodes 62 and 63 of acceleration-sensor 1A are connected to 9d of impedance differential detectors, and the external electrode 61 which is a common electrode is connected to oscillator-circuit 9e. In addition, 9f9 g is resistance for matching. In this case, output V0 which was made to oscillate both resonators 20 and 30 on the same frequency by oscillator-circuit 9e, detected phase contrast or an amplitude difference and is proportional

to acceleration G from the difference in the electric impedance of each resonator 20 and 30 It takes out from 9d of impedance differential detectors. What is necessary is to feed back the output of one of resonators, or the output with which both resonators were added together, and just to constitute oscillator-circuit 9e, in order to make it oscillate on the same frequency. Since the output change by a temperature change etc. can be offset while being able to take out the signal which is proportional to acceleration G like the example of drawing 9 also in this case, the acceleration detection equipment which has sensibility only to acceleration G can be obtained.
[0034] With drawing 9 and the acceleration detection equipment of drawing 10 , although acceleration-sensor 1A of the 1st example was used as an acceleration sensor, other acceleration sensors 1B and 1C shown in drawing 7 and drawing 8 can be used similarly. Also as that by which fixed support only of the end section was carried out by the case member, i.e., cantilever structure, although the acceleration sensors 1A-1C of the above-mentioned example showed the thing of the structure where fixed support of the both ends of a sensing element was all carried out by the case member, they are good. In this case, since the amount of displacement of the free end accompanying impression of acceleration is large, it is possible to obtain a big frequency change or impedance change. Moreover, in the acceleration sensors 1A, 1B, and 1C of the 1st - the 3rd example, although the resonator of the thickness skid oscillation mode was used as resonators 20 and 30, it does not restrict to this and the resonator of other oscillation modes (for example, thickness longitudinal-oscillation mode, the die-length oscillation mode, area crookedness mode, etc.) is also usable.
[0035]
[Effect of the Invention] According to invention according to claim 1, compressive stress can be generated in one resonator in the above explanation, and the resonator of another side can be made to generate tensile stress efficiently from bending deformation of the acceleration sensing element which produces the acceleration sensing element of the pair of the uni-morph structure which joined the resonator and the base plate when acceleration is added since it connected so that a resonator might turn to the direction of repulsion or the opposite direction mutually so that clearly. Therefore, by taking out frequency change or impedance change of both resonators in differential, the signal proportional to acceleration can be acquired and the good acceleration sensor of detection sensitivity can be realized. Moreover, since acceleration is detected using frequency change or impedance change, it

is detectable also with the acceleration of DC or low frequency. Furthermore, since the stress by a temperature change etc. is added common to both resonators, the stress by factors other than acceleration can be offset by taking out the output of both resonators in differential, and the acceleration sensor which has sensibility only in acceleration can be obtained. Moreover, an acceleration sensing element is easy structure, and since the drawer of an electrode is also easy, while being able to constitute small, it can constitute easily also in surface mount die parts (chip).
[0036] Since according to invention according to claim 5 the 1st and the 2nd resonator which consist of a piezo electric crystal with which the electrode was formed in both principal planes were joined and the acceleration sensing element was constituted at the single front rear face of a base plate, compressive stress can be generated in one side of a resonator, and another side can be made to generate tensile stress effectively with acceleration. Therefore, by taking out frequency change or impedance change of both resonators in differential, the signal proportional to acceleration can be acquired, detection sensitivity is good and the acceleration sensor which can moreover have sensibility only to acceleration can be obtained. Like invention which starts claim 1 also in this case, the effect by a temperature change etc. can be canceled, and it is small, and can constitute easily on the components of a chip mold. Furthermore, since it is the structure which joins a resonator to both sides of a single base plate, a width method can be shortened further and a still smaller acceleration sensor can be realized.

[Translation done.]

DESCRIPTION OF DRAWINGS

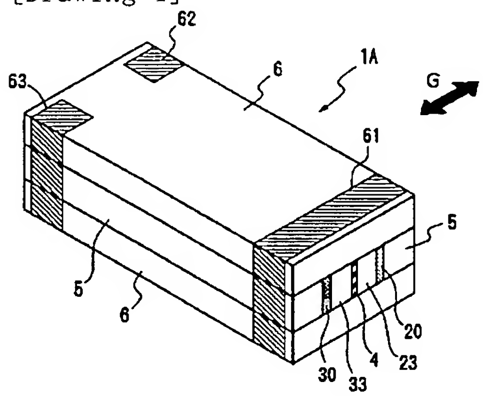
[Brief Description of the Drawings]
[Drawing 1] It is the whole 1st example perspective view of the acceleration sensor concerning this invention.
[Drawing 2] It is the decomposition perspective view of the acceleration sensor shown in drawing 1 .
[Drawing 3] It is a decomposition perspective view except the covering member of an acceleration sensor shown in drawing 1 .
[Drawing 4] It is a side elevation in the condition of having mounted the acceleration sensor shown in drawing 1 in the circuit board.
[Drawing 5] It is the V-V line sectional view of drawing 4 .
[Drawing 6] It is process drawing of an example of the manufacture approach of an acceleration sensor shown in drawing 1 .
[Drawing 7] It is the V-V line sectional view of the 2nd example of the acceleration sensor concerning this invention.
[Drawing 8] It is the V-V line sectional view of the 3rd example of the acceleration sensor concerning this invention.
[Drawing 9] It is the circuit diagram of an example of the acceleration detection equipment using the acceleration sensor concerning this invention.
[Drawing 10] It is the circuit diagram of other examples of the acceleration detection equipment using the acceleration sensor concerning this invention.
[Description of Notations]
1A-1C Acceleration sensor
2, 3, 2', 3', 7 Acceleration sensing element
5 [ ] Case Member
6 [ ] Covering Member
20 30 Resonator
21, 22, 31, 32 Electrode
23, 33, 8 Base plate
51-53 Internal electrode
61-63 External electrode

[Translation done.]

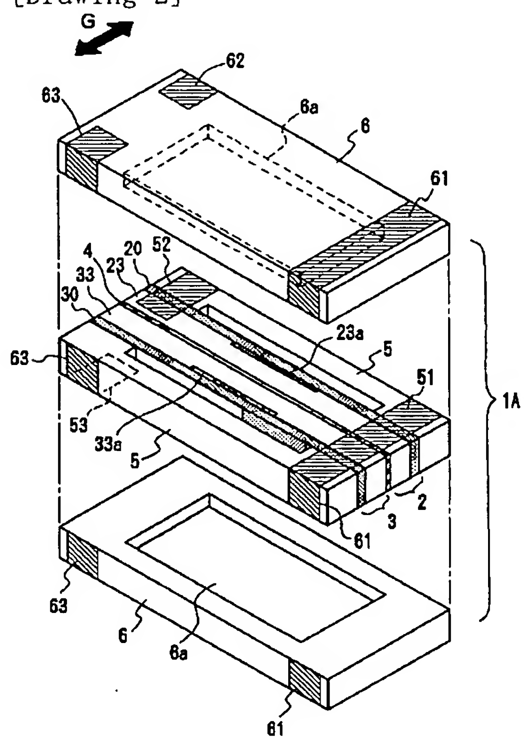
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DRAWINGS

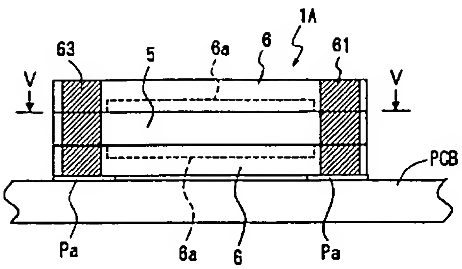
[Drawing 1]



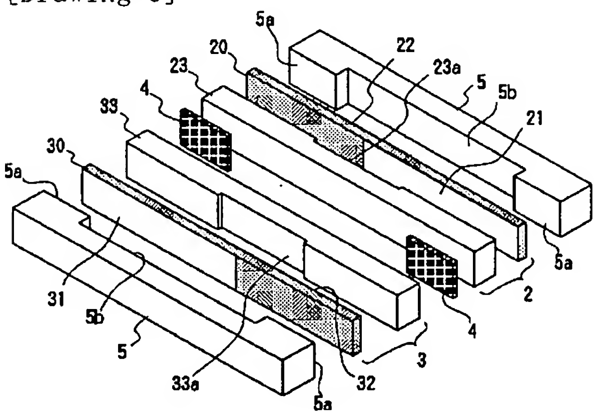
[Drawing 2]



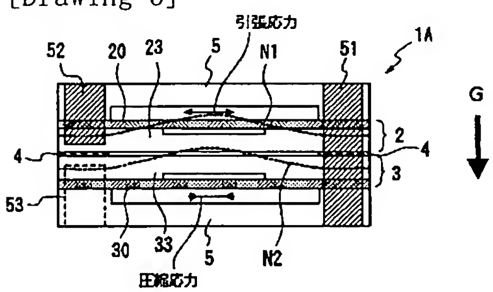
[Drawing 4]



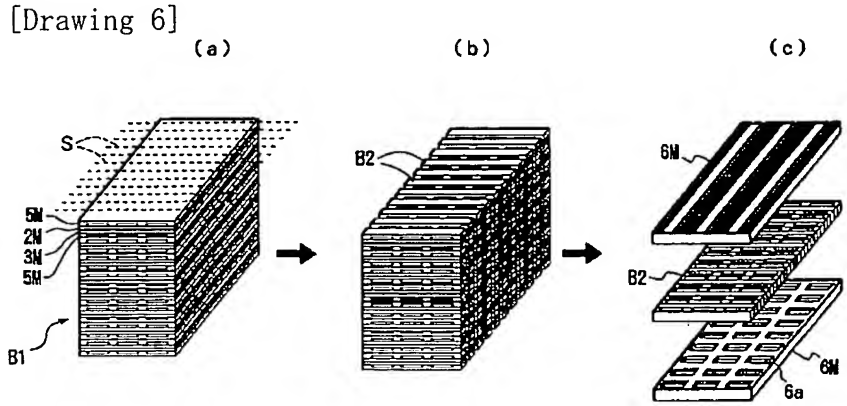
[Drawing 3]



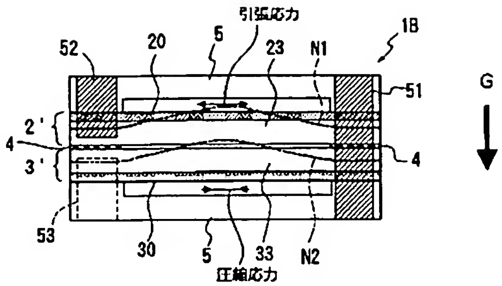
[Drawing 5]



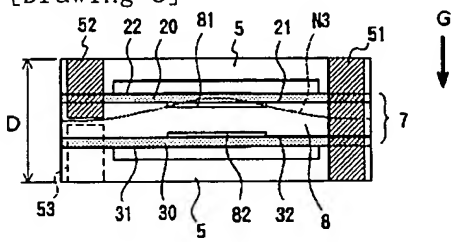
[Drawing 6]



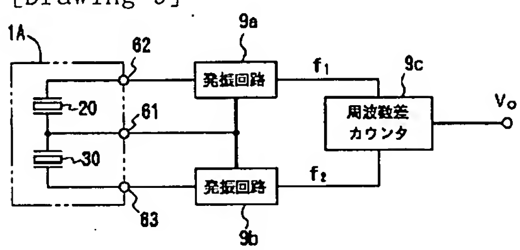
[Drawing 7]



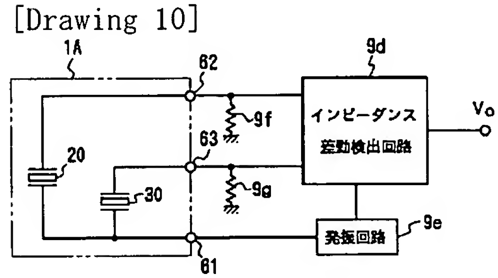
[Drawing 8]



[Drawing 9]



[Drawing 10]



[Translation done.]